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## **DISTRIBUTION, FOOD HABITS, AND GROWTH OF YOUNG CLUPEIDS, CAPE FEAR RIVER SYSTEM, NORTH CAROLINA<sup>1</sup>**

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### **ABSTRACT**

A total of 816 American shad (*Alosa sapidissima*), 2,823 blueback herring (*A. aestivalis*), and 79 alewives (*A. pseudoharengus*) was collected between July and November 1963-1965 to determine distribution, food habits, and growth in the Cape Fear River system, North Carolina. Shad and blueback herring were found in the Cape Fear River from four miles south of Wilmington (20 miles from the mouth) to Lock No. 3, a distance of 99 miles, and in the Black River from the mouth to NC-411 bridge, a distance of 35 miles. In the North East Cape Fear River, shad were distributed from the mouth to NC-24 bridge, a distance of 67 miles, whereas blueback herring were distributed from the river mouth to five miles north of NC-53 bridge, a distance of 44 miles. Alewives were collected in a seven-mile stretch of the Cape Fear River, from four miles south of Wilmington to three miles north of Wilmington and in the North East Cape Fear River from the mouth to Lanes Ferry, a distance of 25 miles. None were collected in Black River. The data showed American shad fed primarily on aquatic and terrestrial insects and crustaceans, and insects were the dominant food, whereas blueback herring and alewife fed chiefly on crustaceans. Only minor differences were found in the food habits of each species within or between rivers. The growth rates of individual species were similar between rivers. Seaward

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migration occurred from October to November and was in association with an increase in water level and a decrease in water temperature.

INTRODUCTION

The Cape Fear River is formed by the confluence of the Deep and Haw Rivers in Chatham County, North Carolina. It flows southeast about 200 miles and empties into the Atlantic Ocean 25 miles south of Wilmington. The principal tributaries are the North East Cape Fear River that enters at Wilmington, and the Black River that enters 16 miles upstream from Wilmington (Figure 1). The Cape Fear River is

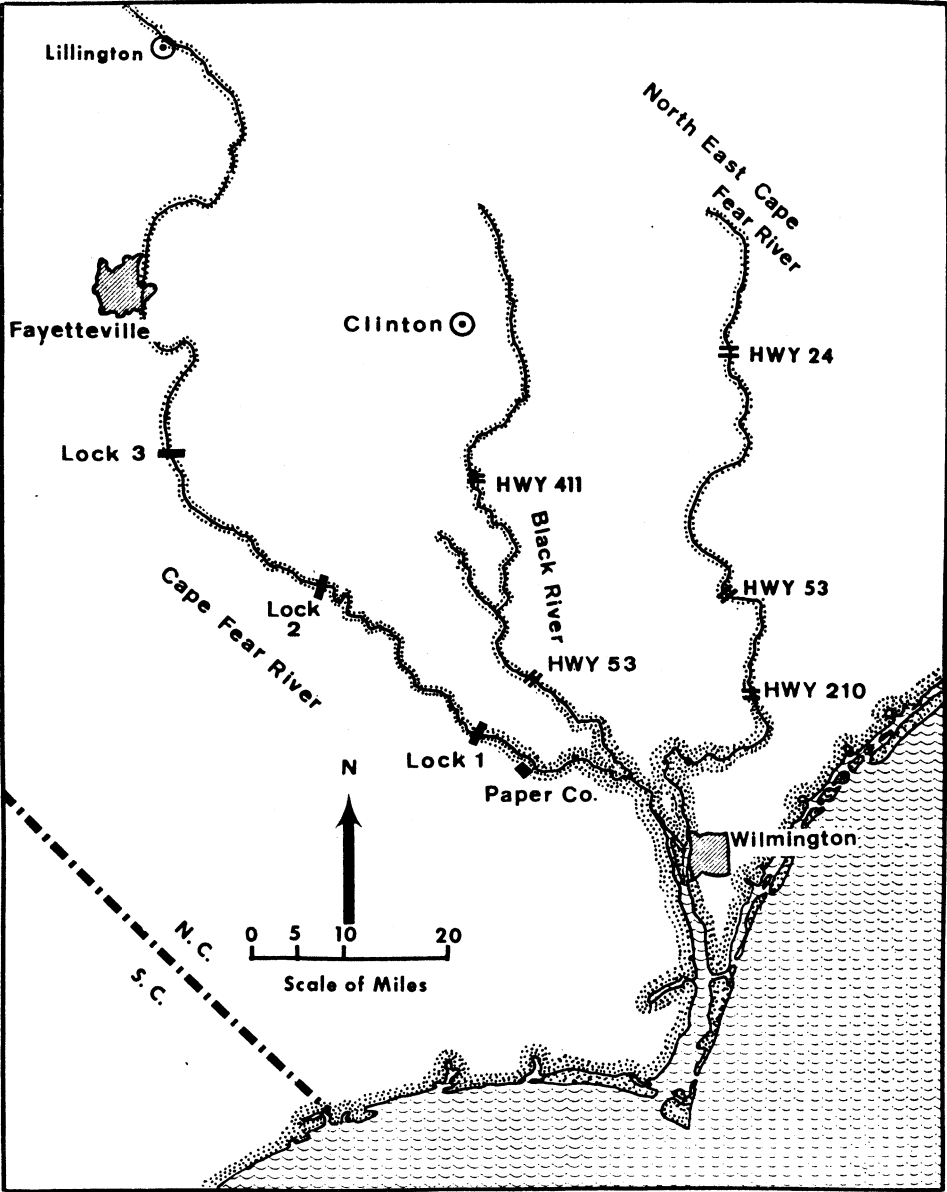


FIGURE 1. Cape Fear River Study Area.

usually highly turbid, whereas the tributaries are blackwater, swamp-drainage streams. Tidal influence extends about 50 miles up the lower Cape Fear River, 25 miles up the lower North East Cape Fear River, and five miles up the lower Black River.

At the turn of the century, the Cape Fear River system was one of the most productive North Carolina streams for clupeids. American shad, *Alosa sapidissima* (Wilson), ascended the Cape Fear River to Smiley Falls near Lillington and spawned from the mouth of the Black River to Fayetteville, a distance of about 100 miles (Cobb, 1906; Stevenson, 1899). The alewife, *A. pseudoharengus* (Wilson), and blueback herring, *A. aestivalis* (Mitchill), also spawned in this reach of the river.

During the period 1913-34, three navigational locks and dams were constructed on the Cape Fear River: Lock No. 1, 65 miles above the mouth in 1913; Lock No. 2, 99 miles above the mouth in 1917; and Lock No. 3, 119 miles above the mouth in 1934. These structures prevented fishes from entering the river above except during boat lockages and periods of extended high flow. The dams were provided with ladder-type fishways, but anadromous fishes did not use them.

In 1962, the Fish and Wildlife Service in cooperation with the U. S. Army Corps of Engineers and the North Carolina Wildlife Resources Commission began studies on the Cape Fear River to determine the practicability of locking anadromous fishes upstream during the spawning migration. A second objective was to determine use of the upper river for spawning and nursery habitat. This paper is part of the study, and reports on distribution, food habits, growth, and time of seaward migration of young shad, blueback herring, and alewives. Previous studies of this nature have been primarily concerned with the food and distribution of young shad only.

#### COLLECTION AND EXAMINATION OF YOUNG CLUPEIDS

From July to November, 1963-65, we collected 816 shad, 2,820 blueback herring, and 79 alewives for this study. Of the total number of specimens collected, 369 shad, 1,497 blueback herring, and seven alewives were taken in the Cape Fear River; 231 shad and 237 blueback herring in the Black River; and 216 shad, 1,086 blueback herring, and 72 alewives in the North East Cape Fear River.

Fishes were collected by surface trawl and five percent emulsifiable rotenone. The trawl ( $\frac{1}{2}$ -inch mesh nylon netting with a four- by 12-foot opening, and 15 feet long, tapered to form a cod end) was pulled by two boats powered by 18-horse-power outboard motors (Figure 2). Rotenone was applied in midstream over an area of approximately 1,000 square feet. It was quickly diluted by the moving water and usually maintained effectiveness for approximately 150 yards. Each area was observed from one-half to one hour after the rotenone was applied. When distressed fish first appeared at the surface, they were taken with long-handled dip nets.

Collections were labeled and preserved in 10 percent formalin in the field and later identified in the laboratory since the young of these species appear very similar (Figure 3). Shad were separated from blueback herring and alewives by the outline of the lower jaw and shape of the cheek patch (Figure 4). Blueback herring and alewives were separated on the basis of eye size and color of the peritoneum; the alewife has a large eye and pale peritoneum.

The frequency-of-occurrence method was used to determine the food habits of the three species. Stomach contents were examined under a binocular microscope and identified to Order according to keys by Pen-nak, 1953.

Water samples were collected at each sampling station and dissolved oxygen, total alkalinity, free carbon dioxide, water temperature, and pH were determined.

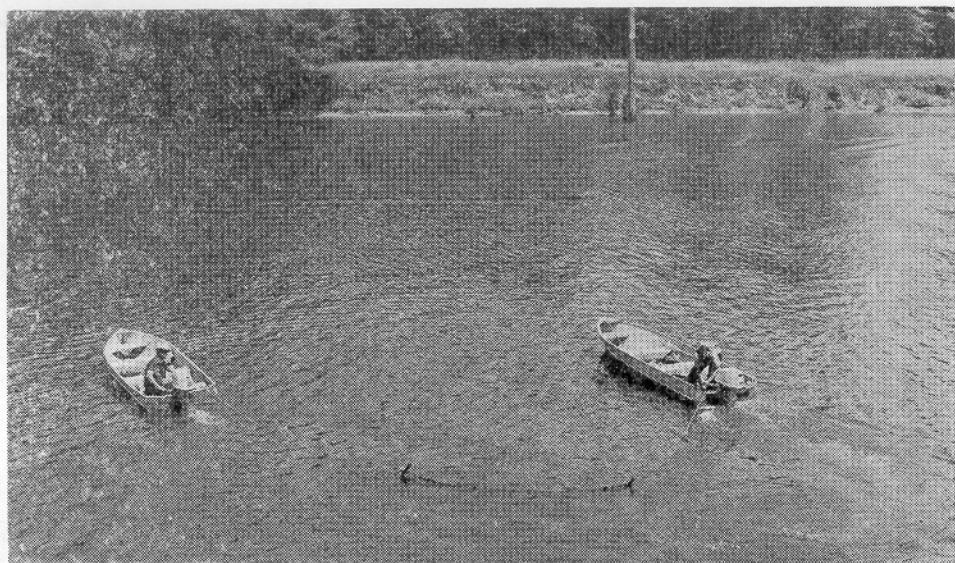


FIGURE 2. Trawling for young Clupeid fishes in the Cape Fear River.

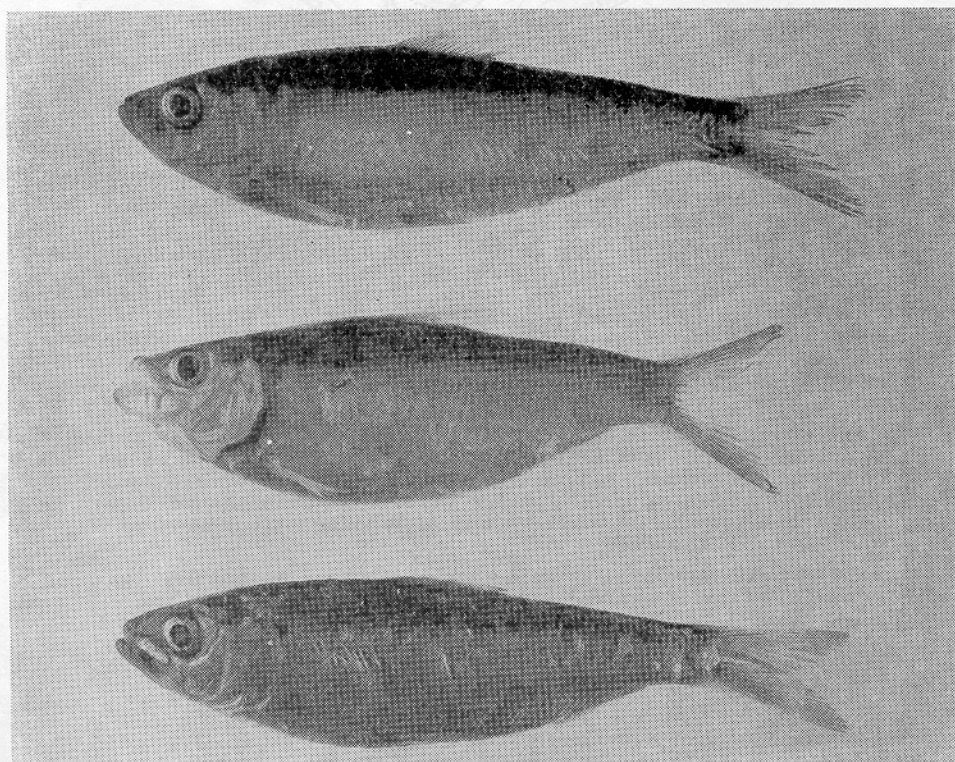
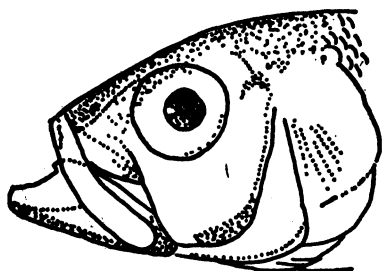
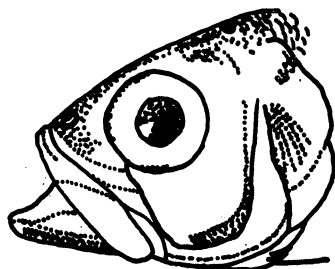


FIGURE 3. Young-of-year Blueback Herring, Alewife and American Shad.  
 Blueback Herring — 104 mm. fork length  
 Alewife — 93 mm. fork length  
 American Shad — 103 mm. fork length



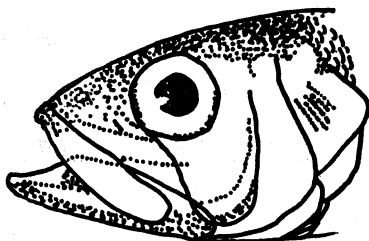
**Blueback Herring**

(*Alosa aestivalis*)



**Alewife**

(*Alosa pseudoharengus*)



**American Shad**

(*Alosa sapidissima*)

FIGURE 4. Outline drawings of heads of American Shad, Alewife and Blueback Herring. Note outline of lower jaw and cheek patch on each. (Taken from Hildebrand and Schroeder, 1928.)

#### DISTRIBUTION

The number of clupeids collected for distribution studies and associated water conditions are given in Table 1. In 1963, collections were limited to the Cape Fear River, whereas in 1964 and 1965, sampling was conducted in the Cape Fear, Black, and North East Cape Fear Rivers.

**1963:** From August to October we made collections with surface trawl and rotenone from Lock and Dam No. 2 downstream to the vicinity of Riegel Paper Corporation (32 miles north of Wilmington). Sixty-three American shad and 190 blueback herring were collected throughout this area. In November we sampled from Riegel Paper Corporation downstream to the vicinity of Wilmington, but no clupeids were taken.

**1964:** All three streams were sampled this year for the first time. In the Cape Fear, from mid-July to early November, we collected from 17 miles above Lock No. 3 downstream to four miles south of Wilmington; in the Black, from mid-August to early November, from NC-411 bridge to the river mouth; and in the North East Cape Fear, from mid-August to early November, from NC-24 bridge to the river mouth.

Young shad were collected from 17 miles above Lock No. 3 downstream to four miles south of Wilmington in the Cape Fear (115 miles); from NC-411 bridge to the mouth of the Black (35 miles); and from NC-24 bridge to the mouth of the North East Cape Fear (67 miles).

Blueback herring were collected from Lock No. 3 downstream to four miles south of Wilmington in the Cape Fear (98 miles); from NC-411 bridge downstream to the mouth in the Black (35 miles); and from

TABLE 1  
COLLECTIONS OF YOUNG CLUPEID FISHES  
WITH ASSOCIATED WATER CONDITIONS,  
CAPE FEAR RIVER SYSTEM 1963-65

YEAR	RIVER	SHAD <u>NUMBER</u>	BLUEBACK HERRING <u>NUMBER</u>	ALEWIVES <u>NUMBER</u>	WATER TEMPERATURE RANGE <u>°F</u>	CO <sub>2</sub> RANGE <u>PPM</u>	ALKALINITY RANGE <u>PPM</u>	O <sub>2</sub> RANGE <u>PPM</u>	pH RANGE	RELATIVE WATER LEVELS
1963	Cape Fear	63	190	0	53-89	8-10	16-18	5.4-8.4	6.9	Low
1964	Cape Fear	169	1120	7	57-80	4-19	7-32	4.0-8.6	6.5-6.7	Normal
	Black	146	226	0	58-82	7-20	5-15	2.8-7.0	5.4-6.2	Normal
	North East Cape Fear	58	517	64	57-84	8-22	7-22	2.4-6.8	5.2-6.6	Normal
1965	Cape Fear	137	187	0	56-84	5-15	14-22	5.0-10.0	6.5-6.8	High
	Black	85	11	0	56-80	8-13	5-16	3.0-6.4	6.0-6.2	High
	North East Cape Fear	158	569	8	56-80	7-14	7-22	3.0-6.4	6.2-6.7	High

NC-210 bridge (Lanes Ferry) downstream to the mouth in the North East Cape Fear (25 miles).

Alewives were found in the Cape Fear from three miles north of Wilmington to four miles south of Wilmington (seven miles); in the North East Cape Fear from NC-210 bridge to the mouth (25 miles). None were found in the Black.

1965: We sampled the Cape Fear from Lillington (approximately 50 miles upstream from Lock No. 3) downstream to four miles south of Wilmington from late July until early November. Young shad were collected from Lock No. 2 downstream to three miles north of Wilmington (67 miles). Blueback herring were collected from Lock No. 1 downstream to three miles north of Wilmington (36 miles). No alewives were collected.

In the Black River, we sampled from NC-411 bridge to the mouth from mid-August until early November. Young shad were collected from seven miles above NC-53 bridge downstream to the mouth (17 miles). Young blueback herring were collected from two miles above NC-53 bridge downstream to one mile below NC-53 bridge. As in 1964, no alewives were found.

The North East Cape Fear River was sampled from mid-August until early November from NC-24 bridge downstream to the mouth. Shad and blueback herring were collected from five miles above NC-53 bridge to the mouth (44 miles). Alewives were collected from NC-210 downstream to the mouth (25 miles).

In all years, the seaward migration of the young occurred either in October or November and was associated with a rise in water level and a decrease in water temperature. At Lock No. 1, in 1963, water levels increased from 15.0 to 19.9 feet and water temperatures decreased from 62° to 52° F. between November 6 and 10; in 1964 water levels increased from 16.3 to 25.0 feet and water temperatures decreased from 72° to 60° F. between October 1 and 10; and in 1965 water levels increased from 16.1 to 18.2 feet and water temperature decreased from 70° to 64° F. between October 15 and 25.

## FOOD HABITS

Stomachs from 739 shad, 819 blueback herring, and 76 alewives were examined to determine the food habits of each species in the three rivers. The stomach contents of each species were compared within and between rivers, and between years. No differences in food habits occurred between years and only minor differences were found within or between rivers so the data for all three years were combined by river for each species (Tables 2-4).

*Shad*: Shad stomachs collected from the Cape Fear River contained more food than those collected in the Black and North East Cape Fear Rivers. Only minor differences in food items were noted between tidal and nontidal areas of the rivers. Food items were quite consistent between stomachs, and crustaceans or insects were numerically dominant. Flies, gnats, water boatmen, and flying ants were the insects most commonly encountered. Diptera larvae occurred in 46.8 percent of all shad stomachs, but in such low numbers as to insignificantly affect the total volume. Insect parts, with an average frequency of 81.6 percent from all rivers, were from the identified Orders. Aquatic crustaceans were the second most numerous group. Some stomachs collected from the Cape Fear were extremely full of crustaceans. Cladocerans occurred more frequently than any other group and had an average frequency of 81.6 percent from all rivers. Only five stomachs were empty; all of these were collected from the headwaters of Black River. Gravel was occasionally encountered in shad stomachs, particularly those collected from the shallow headwaters of Black River. Phytoplankton was not observed in any shad stomachs. Fish larvae were digested to a point which prevented identification to species.

*Blueback herring*: The food items of the young blueback herring did not vary as much as those of the American shad. Small crustaceans

and crustacean eggs made up the major portion of their diet. Dipterous larvae appeared frequently; however, they did not constitute a major portion of the total volume of stomach contents.

*Alewife:* In young alewives, food habits were similar to those of the young blueback herring even though they were found only in the tidal areas of the Cape Fear and North East Cape Fear Rivers. The mainstay of their diet consisted of cladocerans, copepods, and crustaceans eggs. The major portion of the insect parts were composed of various dipterans.

Much of the stomach material was digested and identification was impossible. Of the insects, legs, mouth parts, elytra, and wings appeared to remain intact in the stomachs over a period of time. Generally, crustaceans were composed of soft tissue and quickly digested.

TABLE 2

FREQUENCY OF OCCURRENCE OF TYPES OF FOOD IN  
STOMACHS OF YOUNG-OF-YEAR AMERICAN SHAD (*ALOSA SAPIDISSIMA*),  
COLLECTED IN CAPE FEAR, BLACK, AND NORTH EAST CAPE FEAR RIVERS,  
NORTH CAROLINA, 1963-65

(Expressed as percentage of number of fish examined.)

TYPE OF FOOD	RIVERS			TYPE OF FOOD	RIVERS		
	CAPE FEAR	BLACK	NORTH EAST CAPE FEAR		CAPE FEAR	BLACK	NORTH EAST CAPE FEAR
<i>Nematoda</i>	1.8	10.8	10.9	<i>Trichoptera</i>	1.5	1.5	0.0
<i>Cladocera</i>	37.7	17.4	27.0	<i>Coleoptera</i>	14.0	13.8	8.5
<i>Copepoda</i>	26.7	8.2	12.3	<i>Diptera (larvae)</i>	39.2	46.7	54.5
<i>Ostracoda</i>	20.1	19.8	27.9	<i>Diptera (adults)</i>	20.4	17.4	26.1
<i>Isopoda</i>	0.3	0.0	1.4	<i>Hymenoptera</i>	19.8	17.9	17.1
<i>Amphipoda</i>	10.9	3.6	13.3	<i>Insect eggs</i>	12.2	15.4	13.7
<i>Hydracarina</i>	0.0	0.0	1.4	<i>Insect parts</i>	78.7	76.9	89.1
<i>Crustacean (eggs)</i>	19.4	4.6	11.8	<i>Insects</i>	7.3	19.5	4.3
<i>Arachnida</i>	2.1	7.7	7.1	<i>Fish larvae</i>	1.2	0.0	1.9
<i>Ephemeroptera</i>	0.0	0.0	1.4	<i>Unidentifiable</i>			
<i>Odonata</i>	2.7	3.1	5.2	<i>animal remains</i>	11.2	5.1	15.6
<i>Hemiptera</i>	10.3	7.7	11.4	<i>Gravel</i>	0.6	2.6	1.4

TABLE 3.

FREQUENCY OF OCCURRENCE OF TYPES OF FOOD  
IN STOMACHS OF YOUNG-OF-YEAR BLUEBACK  
HERRING (*ALOSA AESTIVALIS*), COLLECTED IN  
CAPE FEAR, BLACK, AND NORTH EAST CAPE  
FEAR RIVERS, NORTH CAROLINA, 1963-65

(Expressed as percentage of number of  
fish examined.)

TYPE OF FOOD	RIVERS		
	CAPE FEAR	BLACK	NORTH EAST CAPE FEAR
<i>Nematoda</i>	12.9	33.3	16.4
<i>Cladocera</i>	95.9	95.7	95.8
<i>Copepoda</i>	83.6	78.5	69.2
<i>Ostracoda</i>	35.2	33.3	26.2
<i>Amphipoda</i>	6.2	2.2	4.2
<i>Hydracarina</i>	9.8	4.3	0.5
<i>Crustacean (eggs)</i>	88.9	91.4	80.8
<i>Diptera</i>	29.5	66.7	42.0
<i>Insect eggs</i>	1.8	2.2	6.5
<i>Insect parts</i>	15.0	14.0	20.6

TABLE 4

FREQUENCY OF OCCURRENCE OF TYPES OF FOOD  
IN STOMACHS OF YOUNG-OF-YEAR ALEWIVES  
(*ALOSA PSEUDOHARENGUS*) COLLECTED IN CAPE  
FEAR AND NORTH EAST CAPE FEAR RIVERS,  
NORTH CAROLINA, 1964-65

(Expressed as percentage of number of  
fish examined.)

TYPE OF FOOD	RIVERS	
	CAPE FEAR	NORTH EAST CAPE FEAR
<i>Nematoda</i>	0.0	18.8
<i>Cladocera</i>	57.1	95.6
<i>Copepoda</i>	57.1	15.9
<i>Ostracoda</i>	28.6	50.7
<i>Amphipoda</i>	0.0	10.1
<i>Hydracarina</i>	14.3	7.2
<i>Crustacean (eggs)</i>	57.1	87.0
<i>Diptera</i>	0.0	31.9
<i>Insect eggs</i>	0.0	20.3
<i>Insect parts</i>	0.0	40.6



## GROWTH

Growth rates of the young clupeids were determined monthly by measuring the mean fork length of each species (Tables 4-7). The growth rate for young shad in the Cape Fear River was greatest in 1963, increasing from a mean fork length of 48.7 mm in August to 100.6 mm in October. In the Black and North East Cape Fear Rivers, young shad grew faster in 1965 than in 1964. In 1964, the growth rate of shad was greatest in the Cape Fear River but in 1965 the growth rates were similar between the Cape Fear and Black Rivers and least in the North East Cape Fear River.

The growth rate for young blueback herring in the Cape Fear was

TABLE 5

SIZE COMPOSITION OF YOUNG SHAD (*ALOSA SAPIDISSIMA*) COLLECTED MONTHLY  
IN THE CAPE FEAR, BLACK, AND NORTH EAST CAPE FEAR RIVERS,  
NORTH CAROLINA, 1963-65

YEAR	MONTH	CAPE FEAR RIVER			BLACK RIVER			NORTH EAST CAPE FEAR RIVER		
		NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH	NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH	NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH
			mm	mm		mm	mm		mm	mm
1963	August	3	41- 63	48.7	-	-	-	-	-	-
	October	54	81-119	100.6	-	-	-	-	-	-
	November	6	89-104	97.7	-	-	-	-	-	-
1964	July	52	48- 88	65.6	-	-	-	-	-	-
	August	47	53- 88	65.7	96	33- 78	51.6	34	38- 83	53.2
	September	35	53- 83	67.6	48	44- 73	55.3	24	43- 78	57.0
	October	32	58- 98	73.0	-	-	-	-	-	-
	November	3	61- 90	75.5	2	66- 80	73.0	-	-	-
1965	July	12	44- 80	51.0	-	-	-	-	-	-
	August	31	45- 81	60.0	21	51- 82	62.0	17	48- 81	57.0
	September	89	51- 95	69.3	58	51- 80	68.0	96	41- 90	61.0
	October	3	61- 80	73.7	6	71- 95	80.0	45	56- 80	69.0
	November	2	61- 65	64.0	-	-	-	-	-	-

TABLE 6

SIZE COMPOSITION OF YOUNG BLUEBACK HERRING (*ALOSA AESTIVALIS*) COLLECTED MONTHLY  
IN THE CAPE FEAR, BLACK, AND NORTH EAST CAPE FEAR RIVERS,  
NORTH CAROLINA, 1963-65

YEAR	MONTH	CAPE FEAR RIVER			BLACK RIVER			NORTH EAST CAPE FEAR RIVER		
		NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH	NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH	NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH
			mm	mm		mm	mm		mm	mm
1963	August	30	52- 63	56.5	-	-	-	-	-	-
	October	153	74-105	87.2	-	-	-	-	-	-
	November	7	85- 97	91.1	-	-	-	-	-	-
1964	July	17	39- 59	49.3	-	-	-	-	-	-
	August	189	34- 64	49.3	32	42- 53	46.6	39	36- 48	41.4
	September	15	39- 56	48.7	30	37- 53	45.8	105	41-105	45.9
	October	3	63- 66	64.3	-	-	-	-	-	-
	November	12	51- 68	57.4	17	53- 77	59.5	-	-	-
1965	August	19	33- 58	42.4	10	44- 58	49.8	45	27- 44	34.3
	September	24	42- 66	48.4	-	-	-	10	37- 53	42.9
	October	21	46- 54	49.0	4	54- 65	60.5	15	36- 43	39.2
	November	22	47- 87	58.8	-	-	-	-	-	-

TABLE 7

SIZE COMPOSITION OF YOUNG ALEWIVES (*ALOSA PSEUDOHARENGUS*)  
COLLECTED MONTHLY IN THE CAPE FEAR AND NORTH EAST CAPE FEAR RIVERS,  
NORTH CAROLINA, 1964-65

YEAR	MONTH	CAPE FEAR RIVER			NORTH EAST CAPE FEAR RIVER		
		NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH	NUMBER MEASURED	SIZE RANGE IN FORK LENGTH	MEAN FORK LENGTH
			mm	mm		mm	mm
1964	August	7	43-47	45.0	61	38-59	44.0
1965	August	-	-	-	8	45-53	47.8

also greatest in 1963; in the Black River, the growth rate was slightly greater in 1965; and in the North East Cape Fear River, the growth rate was greater in 1964. Between rivers, the growth rate in 1964 was greatest in the Cape Fear and least in the North East Cape Fear. However, in 1965, the growth rate was greatest in the Black and again least in the North East Cape Fear.

Young alewives collected in the Cape Fear and North East Cape Fear Rivers in 1964 had similar growth rates. In 1965 they were collected only in the North East Cape Fear River and the growth rate was slightly greater than in 1964.

#### DISCUSSION

Rotenone proved to be the more efficient means of sampling young clupeids in the Cape Fear River system; surface trawling was not practical in the upper, shallow headwater streams. Also, rotenone was effective at all times whereas surface trawling was only effective in the late evening and at night. While young clupeids were very susceptible to weak concentrations of rotenone, game fishes were not seriously affected. Thus, we feel the use of rotenone is an excellent means of sampling for young clupeids if quantitative data are not necessary. Apparently rotenone did not cause regurgitation because of the 1,634 stomachs examined, only five were empty.

Young American shad and blueback herring had the same general distribution pattern in each stream; but shad occurred further upstream in some cases. The alewife was found only in the lower reaches of fresh water in the Cape Fear and North East Cape Fear Rivers (the Cape Fear becomes brackish south of Wilmington). Since most of the clupeids observed at Lock No. One were blueback herring, it is likely that the alewife spawned in the lower reaches of the Cape Fear and North East Cape Fear and did not ascend as far upstream as the Black River.

The seaward migration of young clupeids is apparently stimulated by the first significant decrease in water temperature and increase in water level during October or November.

It appeared that the young shad fed on floating or free-swimming organisms. Stomachs examined from the same sample usually contained organisms that were similar; either insects or crustaceans. Some shad stomachs from the Cape Fear contained extremely large numbers of crustaceans.

Young shad fed entirely on zooplankton as phytoplankton was not found in any of the stomachs. Based on the variety of food items in shad stomachs, shad fed indiscriminately on available organisms but insects and crustaceans were of major importance.

The food habits of young shad in the Cape Fear River system were

similar to those of young shad in other rivers along the Atlantic coast (Massmann, 1963; and Walburg, 1956). However, we could not associate the occurrence of terrestrial insects with the wooded upriver areas, as Massmann (1963) did in Virginia, since the entire study area of the Cape Fear River system was wooded.

Blueback herring were not as diversified in their food habits as shad. Planktonic crustaceans and crustacean eggs were the mainstay of their diet. Of the 819 blueback herring stomachs examined, none were empty, even though stomachs generally were not as full as shad stomachs. Apparently young blueback herring fed to some extent throughout the day because all stomachs were relatively full regardless of the time collected. Food items did not differ greatly between rivers. Phytoplankton, larval fish, or gravel were not found in blueback herring stomachs; the lack of gravel suggesting that herring do not feed on bottom organisms. Apparently, blueback herring are much more selective in their food habits than shad.

Young alewives, though not many were examined, had feeding habits similar to blueback herring.

The young clupeids grew at a fast rate in all rivers; however, the growth rate of young shad was greater than that of either blueback herring or alewives. Growth rates for blueback herring and alewives were similar between years and between rivers.

#### LITERATURE CITED

- American Public Health Association, Inc. 1955. Standard methods for the examination of water, sewage, and industrial wastes. 10th ed. New York, 522 p.
- Cobb, John N. 1906. Investigations relative to the shad fisheries of North Carolina. N. C. Geol. Surv. Econ. Paper 12: 1-39.
- Hildebrand, Samuel F., and William C. Schroeder. 1928. Fishes of Chesapeake Bay. Bull. U. S. Bur. Fish. 43(1): 1-366.
- Massmann, William H., Ernest C. Ladd, and Henry N. McCutcheon. 1952. A surface trawl for sampling young fishes in tidal rivers. Trans. 17th N. Amer. Wildl. Conf.: 386-392.
- Massman, William H. 1963. Summer food of juvenile American shad in Virginia waters. Ches. Sci. 4(4): 167-171.
- Pennak, Robert W. 1953. Fresh-water invertebrates of the United States. Ronald Press Co. New York. 1-769.
- Stevenson, Charles H. 1899. The shad fisheries of the Atlantic coast of the United States. U. S. Comm. Fish and Fish., pt. 24, 1898: 101-269. 1898;101-269.
- Walburg, Charles H. 1956. Observations on the food and growth of juvenile American shad *Alosa sapidissima*. Trans. Amer. Fish. Soc. 86: 302-306.
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